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The Impact of Rhizosphere Processes on Water Flow and Root Water Uptake

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For many years, the rhizosphere, which is the zone of soil in the vicinity of the roots and which is influenced by the roots, is known as a unique soil environment with different physical, biological and chemical properties than those of the bulk soil. Indeed, in recent studies it has been shown that root exudate and especially mucilage alter the hydraulic properties of the soil, and that drying and wetting cycles of mucilage result in non-equilibrium water dynamics in the rhizosphere. While there are experimental evidences and simplified 1D model for those concepts, an integrated model that considers rhizosphere processes with a detailed model for water and roots flow is absent. Therefore, the objective of this work is to develop a 3D physical model of water flow in the soil-plant continuum that take in consideration root architecture and rhizosphere specific properties. Ultimately, this model will enhance our understanding on the impact of processes occurring in the rhizosphere on water flow and root water uptake.

To achieve this objective, we coupled R-SWMS, a detailed 3D model for water flow in soil and root system (Javaux et al 2008), with the rhizosphere model developed by Kroener et al (2014). In the new Rhizo-RSWMS model the rhizosphere hydraulic properties differ from those of the bulk soil, and non-equilibrium dynamics between the rhizosphere water content and pressure head is also considered.

We simulated a wetting scenario. The soil was initially dry and it was wetted from the top at a constant flow rate. The model predicts that, after infiltration the water content in the rhizosphere remained lower than in the bulk soil (non-equilibrium), but over time water infiltrated into the rhizosphere and eventually the water content in the rhizosphere became higher than in the bulk soil.

These results are in qualitative agreement with the available experimental data on water dynamics in the rhizosphere. Additionally, the results show that rhizosphere processes affect the spatial distribution of root water uptake. This suggests that rhizosphere processes effect root water uptake at the plant scale. Overall, these preliminary results demonstrate the impact of rhizosphere on water flow and root water uptake, and the ability of the Rhizo-RSWMS to simulate these processes.

References

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